

# PATENT APPLICATION

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3                   **Inventors: NAOKI WATANABE and**  
4                               **KENJI YAMAGAMI**  
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6   TECHNICAL FIELD

7           The present invention relates to data storage systems, and  
8   relates more particularly to systems, devices, and methods for  
9   creating an initial copy in data storage systems.

10  
11   BACKGROUND

12           The connected economy is information-intensive. Maintaining  
13   an uninterrupted flow of information is important for many  
14   businesses and organizations in this environment. Additionally,  
15   maintaining accurate copies of information is important for  
16   businesses and organizations. Data protection and rapid data  
17   recovery is desired in the event of a disruptive event such as a  
18   power outage.

19           In one type of computing system, a master host (e.g., a  
20   server) is located at a master site and a remote host is located  
21   at a remote site. The remote host is typically geographically  
22   dispersed (e.g., several hundred miles) from the master host.  
23   Each host has its own associated storage system (e.g., a disk  
24   subsystem). Typically, in a remote copy system, the data

1 contained in the master host is copied to the remote host. The  
2 network connecting the master host and the remote host is  
3 typically a Wide Area Network (WAN), such as the Internet.

4 When running a remote copy procedure so that identical data  
5 is stored in the disk subsystem(s) on the master site and the  
6 disk subsystem(s) on the remote site, the network administrator  
7 first initiates an initial copy procedure so that data is copied  
8 from the master site to the remote site. Various known methods  
9 are used to copy data from the master site to the remote site.  
10 However, if the data to be copied is large in amount, then the  
11 time required for copying will be longer in length. For example,  
12 to copy 100 Tera bytes of data by using a network of 100  
13 Megabytes/sec will require 11.57 days.

14 In addition, an initial copy procedure requires interruption  
15 of the host input/output functions.

16 U.S. Patent Nos. 5,742,792 and 6,173,377 each discloses two  
17 data storage systems that are interconnected by a data link for  
18 remote mirroring of data. A host computer directly accesses a  
19 primary volume, and data that is written to the primary volume  
20 is automatically sent over the link to a corresponding secondary  
21 volume. However, these references only disclose providing a  
22 copy from the primary volume to the secondary volume by use of  
23 the network link.

1       Other references related to data transmission are the  
2 following. The "Fibre Channel Physical And Signaling Interface  
3 (FC-PH) Rev. 4.3" standard describes the point-to-point physical  
4 interface, transmission protocol, and signaling protocol of a  
5 high-performance serial link for support of higher level  
6 protocols associated with High-Performance Parallel Interface  
7 (HPPI), Intelligent Peripheral Interface (IPI), Small Computer  
8 System Interface (SCSI), and other standards. The "Fibre  
9 Channel Switch Fabric (FC-SW) Rev. 3.3" standard specifies tools  
10 and algorithms for interconnection and initialization of fibre  
11 channel switches to create a multi-switch fibre channel fabric.  
12 The SCSI standards are several standards defined by the American  
13 National Standard for Information Technology (ANSI). SCSI  
14 Primary Command 2 (SPC-2) is one of the standards of SCSI. SPC-  
15 2 contains the second-generation definition of the basic  
16 commands for all SCSI devices.

17       There is a need for a system and method that will overcome  
18 the above-mentioned deficiencies of conventional methods and  
19 systems. There is also a need for a system and method that will  
20 increase the efficiency of performing the initial copy procedure  
21 in a disk subsystem environment.

22

## SUMMARY

An embodiment of the present invention may advantageously provide an efficient technique for performing the initial copy procedure in a disk subsystem environment that has the remote copy function. An embodiment of the present invention may also advantageously prevent the disruption of the input/output (I/O) operations between a master host and a master disk subsystem when the remote disk subsystem is being moved from the master site (or manufacturer site) to a remote site. An update information area in the master disk subsystem stores any updated information when the remote disk subsystem is being moved to the remote site, thus preventing the disruption of master host I/O operations to the master disk subsystem. In one embodiment, the present invention provides a method of performing an initial copy procedure in a remote copy system. The method includes: configuring a network path between a first disk subsystem and a second disk subsystem to increase the speed of data transmission across the network path; configuring the remote copy system for a remote copy operation; performing an initial copy operation to copy data across the network path from the first disk subsystem to the second disk subsystem; and adjusting the network path to reduce the speed of data transmission across the network path.

In another embodiment, the present invention provides a method of performing an initial copy procedure in a remote copy

1 system, including: setting a storage media at a first site;  
2 performing a split procedure in a first disk subsystem at the  
3 first site; copying data from the first disk subsystem in the  
4 first site to the storage media; moving the storage media from  
5 the first site to a second site; storing the copied data at a  
6 second site; and connecting a network path between the first  
7 disk subsystem and a second disk subsystem at the second site.

8 In another embodiment, the present invention provides a  
9 remote copy system, comprising: a first disk subsystem located  
10 at a first site; and a second disk subsystem capable to be  
11 coupled to the first disk subsystem via a network path, with the  
12 network path capable to be configured to increase or decrease  
13 the speed of data transmission from the first disk subsystem to  
14 the second disk subsystem.

15 In another embodiment, the present invention provides a  
16 remote copy system, including: a first disk subsystem located at  
17 a first site and capable to store data; and a copy engine  
18 capable to capable to copy data stored in the first disk  
19 subsystem to a target device, the first disk subsystem further  
20 capable to store update information while the target device is  
21 placed to a second site.

22

1 BRIEF DESCRIPTION OF THE DRAWINGS

2 Figure 1 is block diagram of an example configuration of a  
3 remote copy system in accordance with an embodiment of the  
4 present invention.

5 Figure 2 is a flowchart of a method of performing an initial  
6 copy by use of a higher speed network, in accordance with an  
7 embodiment of the invention.

8 Figure 3 is a flowchart of a method of performing an initial  
9 copy at the master site, in accordance with an embodiment of the  
10 invention.

11 Figure 4 is a block diagram illustrating a storage media  
12 attached to a master host system, in accordance with an  
13 embodiment of the invention.

14 Figure 5 is a block diagram illustrating a storage media  
15 attached to a master disk subsystem, in accordance with an  
16 embodiment of the invention.

17 Figure 6 is a block diagram of an example of a  
18 configuration of the storage media.

19 Figure 7 is a block diagram showing a split procedure with  
20 a shadow image.

21 Figure 8 is a block diagram showing a split procedure  
22 without a shadow image.

23 Figure 9 is a flowchart illustrating a method of performing  
24 an initial copy at a manufacturer's site, in accordance with an

1 embodiment of the invention.



## DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

In the description herein, numerous specific details are provided, such as examples of system components and methods, to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other systems, methods, components, materials, parts, and the like. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

Reference throughout this specification to "one embodiment", "an embodiment", or "a specific embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrases "in one embodiment", "in an embodiment", or "in a specific embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

Figure 1 is a block diagram of an example configuration of a remote copy system 100 according to a specific embodiment of the invention. The remote copy system 100 includes a master host 101

1 and a remote host 102. The master host 101 is connected to a  
2 master disk subsystem 103 by IO path 106, while the remote host  
3 102 is connected to an associated remote disk subsystem 104 by  
4 path 107. It is noted that the disk subsystems 102 and 104 (and  
5 the various representations of the storage media shown in the  
6 subsequent figures) may be deployed at various places. The  
7 master host 101, remote host 102, master disk subsystem 103, and  
8 remote disk subsystem 104 are connected by a network 105. The IO  
9 path 106 (or the IO path 107) may be, for example, SCSI, fibre  
10 channel, ESCON™, FICON, Ethernet, or any other type of suitable  
11 transmission path. In an embodiment of the invention, the  
12 master disk subsystem 103 uses the network 105 for remote copy  
13 operations. For the remote copy operation, the network 105 may  
14 be a dedicated network, direct connect network, or other  
15 suitable networks.

16 As known to those skilled in the art, SCSI (or Small  
17 Computer System Interface) is a parallel interface standard used  
18 by Apple Macintosh computers, personal computers (PCs), and many  
19 UNIX systems for attaching peripheral devices to computers.  
20 SCSI interfaces provide for faster data transmission rates (up  
21 to about 80 MBps) than standard serial and parallel ports.

22 As also known to those skilled in the art, a fibre channel  
23 is a serial data transfer architecture developed by a consortium  
24 of computer and mass storage device manufacturers and now being

1 standardized by the American National Standards Institute  
2 (ANSI). The most prominent fibre channel standard is the Fibre  
3 Channel Arbitrated Loop (FC-AL) which is designed for new mass  
4 storage devices and other peripheral devices that require a very  
5 high bandwidth. Using optical fibers to connect the devices,  
6 FC-AL supports full-duplex data transfer rates of approximately  
7 100 megabytes per second (MBps).

8 As also known to those skilled in the art, ESCON (or  
9 Enterprise System Connection) are optical fibre connections  
10 between a mainframe computer and its peripherals.

11 As also known to those skilled in the art, FICON (or fibre  
12 connectivity) is a high-speed input/output interface for  
13 mainframe computer connections to storage devices.

14 As also known to those skilled in the art, the Ethernet is  
15 currently the most popular type of local area network, which  
16 sends its communications through radio frequency signals carried  
17 by a coaxial cable. Each computer checks to see if another  
18 computer is transmitting and waits its turn to transmit. If two  
19 computers accidentally transmit at the same time and their  
20 messages collide, the computers wait and send again in turn.  
21 Software protocols used by Ethernet systems vary, but include  
22 Novell Netware and Transmission Control Protocol/Internet  
23 Protocol (TCP/IP).

1       The master host 101 issues request to the master disk  
2 subsystem 103 through input/output interface (IO I/F) 110. The  
3 IO interface 110 may handle certain protocols such as SCSI,  
4 iSCSI, ESCON, Fibre FICON, and/or other suitable protocols. As  
5 known to those skilled in the art, iSCSI (or Internet protocol  
6 small computer system interface) uses the Internet Protocol (IP)  
7 networking infrastructure to quickly transport large amounts of  
8 block storage (SCSI) data over existing local area and/or wide  
9 area networks. With the potential to support all major  
10 networking protocols, iSCSI (IP SAN) can unify network  
11 architecture across an entire enterprise, thus reducing the  
12 overall network cost and complexity. To ensure reliability,  
13 iSCSI can use known network management tools and utilities that  
14 have been developed for IP networks. The iSCSI protocol is  
15 discussed, for example, at the website,  
16 <http://www.ece.cmu.edu/~ips/index.html>) in the IP Storage  
17 section, <http://www.ece.cmu.edu/~ips/Docs/docs.html>.

18       The master host 101 is also connected to network 105  
19 through network interface (I/F) 111. The master host 101 can  
20 communicate via network 105 with various devices such as remote  
21 host 102, master disk subsystem 103, and remote disk subsystem  
22 104.

23       The remote host 102 typically has the same configuration  
24 and similar components and modules as the master host 101. One

1 difference between the master host 101 and the remote host 102  
2 is that the remote host 102 is deployed at a remote site 151 and  
3 is connected to the remote disk subsystem 104.

4 In one embodiment, the master disk subsystem 103 includes a  
5 master disk controller 141 and at least one disk drive 140. The  
6 disk controller 141 typically includes an input/output interface  
7 (IO I/F) 130 that is coupled to path 106 and a network interface  
8 131 that is coupled to network 105. IO interface 130 typically  
9 controls the requests that are received (via path 106) from the  
10 master host 101. Additional IO interfaces 137 and 138 control  
11 the requests to the disk drives 140.

12 In the specific embodiment shown in Figure 1, the disk  
13 drives 140 are connected to the disk controller 141 by IO path  
14 139. The IO path 139 may be, for example, SCSI, fibre channel,  
15 Ethernet, or other suitable types of transmission paths.

16 The disk drives 140 are managed by a central processing  
17 unit (CPU) 133. The CPU 133 typically manages the disk drives  
18 140 into several volumes 142. Typically, the master host 101  
19 may access these volumes 142 and may not the disk drives 140.

20 The CPU 133 controls the disk controller 141 through an  
21 internal bus 132. The internal bus 132 may be, for example,  
22 PCI, InfiniBand, a proprietary bus, or other suitable  
23 transmission paths. As known to those skilled in the art, PCI  
24 (or Peripheral Component Interconnect) is a local bus standard

1 developed by Intel Corporation. Most modern PCs include a PCI  
2 bus in addition to a more general Industry Standard Architecture  
3 (ISA) expansion bus.

4 As also known to those skilled in the art, InfiniBand is an  
5 architecture and specification for data flow between processors  
6 and I/O devices that promises greater bandwidth and almost  
7 unlimited expandability in future computer systems. Offering  
8 throughput of up to about 2.5 gigabytes per second and support  
9 for up to about 64,000 addressable devices, the InfiniBand  
10 architecture also promises increased reliability, better sharing  
11 of data between clustered processors, and built-in security.

12 The disk drives 140 may be configured as RAID, JBOD, or any  
13 other suitable configuration. As known to those skilled in the  
14 art, RAID (or redundant array of independent disks) is a method  
15 of storing the same data in different places (thus, redundantly)  
16 on multiple hard disks. By placing data on multiple hard disks,  
17 input/output operations can overlap in a balanced way, thus  
18 leading to improve performance. Since multiple disks increase  
19 the mean time between failure (MTBF), storing data redundantly  
20 also increases fault-tolerance. A RAID appears to the operating  
21 system to be a single logical hard disk. RAID typically employs  
22 the technique of "striping," which involves partitioning each  
23 drive's storage space into units ranging from a sector (about  
24 512 bytes) up to several megabytes. The stripes of all the

1 disks are interleaved and addressed in order. In a single-user  
2 system where large records, such as medical or other scientific  
3 images, are stored, the stripes are typically set up to be small  
4 (perhaps 512 bytes) so that a single record spans all disks and  
5 can be accessed quickly by reading all disks at the same time.  
6 In a multi-user system, better performance requires establishing  
7 a stripe wide enough to hold the typical or maximum size  
8 records. This allows overlapped disk I/O across drives.

9 As also known to those skilled in the art, JBOD (or "just a  
10 bunch of disks") is used to refer to a computer's hard disks  
11 that have not been configured according to the RAID system to  
12 increase fault tolerance and improve data access performance.  
13 As mentioned above, the RAID system stores the same data  
14 redundantly on multiple disks that nevertheless appear to the  
15 operating system as a single disk. Although, JBOD also makes  
16 the disks appear to be a single disk, JBOD accomplishes this  
17 effect by combining the drives into one larger logical one.

18 In the specific embodiment shown in Figure 1, the disk  
19 controller 141 also includes a memory 134. The memory 134 may  
20 contain a cache memory 135 and control information area 136.  
21 The cache memory 135 stores write data that is sent from the  
22 master host 101 and read data that is read by the master host  
23 101. The cache memory 135 also stores pre-fetched data for  
24 sequential read requests from the master host 101. The control

1 information area 136 stores information that is used for  
2 managing the disk controller 141. Typically, all components  
3 that are deployed in the disk controller 141 can access the  
4 memory 134 through internal bus 132.

5 The remote disk subsystem 104 typically has the same  
6 configuration and similar components and modules as the master  
7 disk subsystem 103. One difference is that the remote disk  
8 subsystem 104 is typically deployed on a remote site 151 and is  
9 connected to the remote host 102.

10 Figure 2 is a flowchart of a method 200 of performing an  
11 initial copy by use of a higher speed network, in accordance with  
12 a specific embodiment of the invention. If the network 105  
13 (which connects the master site 150 and the remote site 151) has  
14 a high throughput (i.e., high data transfer rate), then the time  
15 for copying data from the master site 150 to the remote site 151  
16 might be reduced. It is noted that a network is typically very  
17 expensive. In this specific embodiment shown in Figure 2, the  
18 network administrator selects a higher network throughput by  
19 temporarily using the network 105 for the initial copy procedure.  
20 When the initial copy procedure is completed, the administrator  
21 may then use a smaller number of network paths. In other words,  
22 the method 200 uses a network with a higher throughput for the  
23 initial copy as compared to a normal remote copy procedure.



1       A method of performing an initial copy procedure using  
2 multiple paths in a network is now described in accordance with  
3 an embodiment of the invention. The network administrator  
4 deploys (201) the remote disk subsystem 104 on the remote site  
5 151. The multiple or high speed network path is then connected  
6 (202) between the master disk subsystem 103 and the remote disk  
7 subsystem 104. This procedure may, for example, involve choosing  
8 multiple paths in the network to transmit the initial copy data  
9 or by increasing the throughput (data transfer rate  
10 characteristic) within one physical line to increase the line  
11 performance during the initial copy procedure. The administrator  
12 then configures (203) the settings required for performing an  
13 initial copy. If the administrator uses only just the higher  
14 speed network path, then the administrator uses the same number  
15 of path as in a remote copy procedure. Typically, the  
16 administrator does not select different settings as those used in  
17 a remote copy procedure. After the settings are selected, the  
18 administrator can begin (204) the initial copy procedure. During  
19 the initial copy procedure, the master host 101 can typically  
20 continue to send requests to the master disk subsystem 103.

21       The master disk subsystem 103 stores updated information  
22 (including data) in the memory 134. In one embodiment, the  
23 master disk subsystem 103 periodically sends at least some of the  
24 data in the memory 134 to the remote disk subsystem 104.

1       After the initial copies have been made, the administrator  
2       may re-configure (205) the network path. This re-configuration  
3       procedure may, for example, include reducing the number of paths  
4       in the network 105 and/or reducing the network path performance  
5       on contract with a network provider. After the paths in the  
6       network 105 is reduced, normal remote copy procedures may then be  
7       performed.

8       Figure 3 is a flowchart of a method 300 of performing an  
9       initial copy at the master site 150, in accordance with an  
10      embodiment of the invention. As noted above, the network 105 may  
11      be very expensive to use and/or implement. Thus, the specific  
12      embodiment shown in Figure 3 provides a less costly and higher  
13      speed network at the master site 150. During the initial copy  
14      procedure, the administrator deploys a storage media (e.g., a  
15      tape, tape drive, digital video disc (DVD), compact disc  
16      recordable (CD-R), disk, disk drive, computer device, disk 140  
17      for the disk subsystem 103, the disk subsystem 103, or any other  
18      suitable device) on the master site 150 and connects the storage  
19      media to a higher speed local network in the master site 150.  
20      Data copy may then be performed at the master site 150 to achieve  
21      a higher initial copy performance. This method provides a less  
22      expensive initial copy procedure than using a high speed network  
23      for the initial copy. After performing the initial copy, the

1 storage media may then be moved to the remote site 151 for  
2 coupling to the remote host 102.

3 In the specific embodiment shown in Figure 3, the storage  
4 media is initially set up (301) at the master site 150. A split  
5 procedure is then performed (302). For example, the split  
6 procedure is described further below with reference to Figure 7  
7 and Figure 8. Data is then copied (303) from the master disk  
8 subsystem 103 to the storage media. The storage media is then  
9 moved (304) to the remote site 151. The remote disk subsystem  
10 104 is then deployed (305) on the remote site 151. It is noted  
11 that the procedures in block (304) and block (305) are  
12 interchangeable. For example, if the remote disk subsystem has  
13 already been deployed on the remote site, then the storage media  
14 can then be moved and coupled to the remote disk subsystem.

15 In method 300, the subsequent steps are based on a  
16 determination (306) on whether the storage media is a removable  
17 media or a disk (or disks) of the remote disk subsystem 104. If  
18 the storage media includes a removable media, then the data is  
19 copied (307) to the remote disk subsystem 104. If the storage  
20 media includes at least one disk of the remote disk subsystem  
21 104, then the disk (or disks) are configured (308) as part of  
22 the remote disk subsystem 104. In configuration step (308), the  
23 administrator puts the disk(s) into and connects the disk(s) to  
24 the remote disk subsystem 104. The administrator configures the

1 disk drive as part of the remote disk subsystem 104 by using a  
2 management console (not shown) for the remote disk subsystem  
3 104.

4 The network 105 path between the master disk subsystem 103  
5 and the remote disk subsystem 104 is then connected (309). The  
6 administrator may then configure (310) the system 100 for a  
7 remote copy procedure. Data stored in the system 100 may also  
8 be re-synchronized so that data in the remote disk subsystem 104  
9 is identical to the data in the master disk subsystem 103.

10 Figure 4 is a block diagram illustrating a storage media  
11 402 attached to the master host system 101, in accordance with a  
12 specific embodiment of the invention. The configuration shown  
13 in Figure 4 permits data to be copied to the storage media 402.  
14 The storage media 402 (or other storage media disclosed or  
15 described herein) may be, for example, a tape, tape drive,  
16 digital video disc (DVD), compact disc recordable (CD-R), disk,  
17 disk drive, computer device, disk 140 for the disk subsystem  
18 103, the disk subsystem 103, or any other suitable device. The  
19 storage media 402 is deployable on the remote site 151.

20 The master host 101 copies data to the storage media 402.  
21 In one embodiment, a program 401, such as a copy program  
22 (engine), is used to execute the copy procedure. The copy  
23 program 401 reads data stored in the master disk subsystem 103  
24 and writes the data to the storage media 402.

1        Figure 5 is a block diagram illustrating a storage media  
2        502 attached to the master disk subsystem 103, in accordance  
3        with another specific embodiment of the invention. Similar to  
4        the storage media 402, the storage media 502 may be, for  
5        example, a tape, tape drive, DVD, CD-R, disk drive, computer  
6        device, disk 140 for the disk subsystem 103, the disk subsystem  
7        103, or any other suitable device. The storage media 502 is  
8        deployable on the remote site 151. In the configuration shown  
9        in Figure 5, the master disk subsystem 103, the master host 101,  
10       or the media 502 can perform a data copy procedure as described  
11       below.

12       The master host 101 can copy data by using the extended  
13       copy command which is defined by SCSI-3 (SPC2). As known to  
14       those skilled in the art, SCSI-3 is directed to the following  
15       goals: more devices on a bus (up to approximately 32); faster  
16       data transfer; greater distances between devices (longer  
17       cables); more device classes and command sets; structured  
18       documentation; and a structured protocol model. By embedding  
19       clock information into a serial data stream signal, SCSI-3  
20       eliminates delay problems. Driving a single signal also  
21       consumes less driving power and reduces connector cost and size.  
22       To allow for backward compatibility and for added flexibility,  
23       SCSI-3 allows the use of several different transport mechanisms,  
24       some serial and some parallel. The software protocol and

1 command set is the same for each transport. This leads to a  
2 layered protocol definition similar to definitions found in  
3 networking.

4 The master disk subsystem 103 can act as an "initiator" in  
5 order to copy data. If the master disk subsystem 103 can act as  
6 an initiator, the master disk subsystem 103 includes the copy  
7 program 501, and this program 501 copies data from the master  
8 disk subsystem 103 (the initiator) to the storage media 502 (the  
9 "target").

10 The storage media 502 can also act as an initiator in order  
11 to copy data. If the storage media 502 acts as initiator, then  
12 the storage media 502 includes the copy program 501, and this  
13 program 501 copies data from the master disk subsystem 103 (the  
14 target) to the storage media 502 (the initiator). It is noted  
15 that the copy program 501 is shown in Figure 5 as being included  
16 in the master host 101 for purposes of discussion and example  
17 only, and this illustrated configuration is not intended to be  
18 limiting.

19 Figure 6 is a block diagram of an example of a  
20 configuration of the storage media 402 or 502. In the specific  
21 embodiment shown in Figure 6, the storage media includes at  
22 least one disk drive 601, where each disk drive 601 is typically  
23 configured as a disk drive of the remote disk subsystem 104  
24 (Figure 1). The master disk controller 141 copies data from the

1 disk drives 140 to the disk drives 601. When the storage media  
2 is set up in the master site 150 and coupled to the master host  
3 101, the administrator should initiate the split procedure (302)  
4 as shown in Figure 3. This split procedure is performed in the  
5 master disk subsystem 103, as illustrated by the arrow 802 in  
6 Figure 8.

### 7 8 Split Procedure

9 When a split occurs, the master disk subsystem 103 keeps  
10 the update information until the administrator issues a re-  
11 synchronization command. The update information may be, for  
12 example, a bit map that indicate the updated data as "1" and the  
13 non-updated data as "0". Those update information will be used  
14 during the re-synchronization procedure. The administrator  
15 copies data from the disk drives 140 to the storage media (e.g.,  
16 storage media 402 or 502).

17 The split procedure can be performed in two ways: (1) split  
18 procedure with shadow image, and (2) split without shadow image.

### 19 20 Split Procedure With Shadow Image

21 Figure 7 is a block diagram showing a split procedure with  
22 a shadow image. In this example, the master disk subsystem 103  
23 includes a shadow image function as described below. A shadow  
24 image is a replicate of an information, where the replicate is

1 created without typically disrupting operations and overall  
2 performance levels. The sub volumes 702 provides a shadow image  
3 (same volume image) of the information in primary volumes 701  
4 within the master disk subsystem 103. When the master host 101  
5 writes (updates) data in the primary volumes 701 (as illustrated  
6 by arrow 703), the shadow image function also writes (updates)  
7 the same data into the sub volumes 702 (as illustrated by arrow  
8 704).

9 As an example, when the split procedure is executed, sub  
10 volumes 706 are isolated from the primary volumes 705. When the  
11 master host 101 writes (updates) data in the primary volumes 705  
12 (as illustrated by arrow 708), the update information is stored  
13 in the update information area 707 (as illustrated by arrow  
14 709). Thus, the update information is not stored in the sub  
15 volume 706 (which is configured to store a shadow image of  
16 primary volumes 705) because volumes 705 and 706 are isolated  
17 from each other due to the split condition. When the split  
18 procedure is completed, the administrator copies data from sub  
19 volumes 706 to the storage media 710. When the data copy to the  
20 storage media 710 is completed, the administrator moves the  
21 storage media 710 to the remote site 151, and the administrator  
22 can then copy data to the remote disk subsystem 104. The  
23 administrator can also re-synchronize by copying the update  
24 information area 707 and the data in the primary volumes 705 to



1 the remote disk subsystem 104 by, for example, use of a suitable  
2 connection. The administrator may, for example, use these data  
3 for another purpose, because this method provides data  
4 consistency at the split.

#### 6 Split Procedure Without Shadow Image

7 Figure 8 is a block diagram showing a split procedure  
8 without a shadow image. In this example, the master disk  
9 subsystem 103 does not require the shadow image function. The  
10 master host 101 can write (update) data in the primary volumes  
11 801 (as illustrated by arrow 802).

12 As an example, when a split procedure is executed, the  
13 master disk subsystem 103 stores update information in the  
14 update information area 804 (as illustrated by arrow 806). When  
15 the master host 101 writes (updates) data in the primary volumes  
16 803 (as illustrated by arrow 805), this update information is  
17 also stored in the update information area 804 (as illustrated  
18 by arrow 806). When the split procedure is completed, the  
19 administrator copies data from sub volumes 803 to the storage  
20 media 807. When the copy of the data to the storage media 807  
21 is completed, the administrator can move the storage media 807  
22 to the remote site 151, and the administrator can copy the data  
23 to the remote disk subsystem 104. The administrator can re-  
24 synchronize by using the update information area 804 and data

1 primary volumes 803, as similarly described above. In this  
2 particular case, the media 807 may have no consistency, but re-  
3 synchronization works well by using the update information area  
4 804.

5 After the split procedure, the administrator may copy the  
6 data from the master disk subsystem 103 to the storage media (as  
7 also illustrated above in block 303 in Figure 3). The data  
8 copied to the storage media will be configured as the remote  
9 copy data for storage in the remote disk subsystem 104 (Figure  
10 1). It is noted that the copy method in block 303 may vary and  
11 may depend on the environment of the administrator. When the  
12 data copy to the storage media is completed, the administrator  
13 may move the storage media from the master site 150 to the  
14 remote site 151 (as also illustrated above in block 304). It is  
15 noted that the method of moving the storage media to the remote  
16 site 151 may be performed by various techniques. The  
17 administrator also deploys the remote disk subsystem 104 to the  
18 remote site 151 (as also illustrated above in block 305). If  
19 there is already a disk subsystem 104 on the remote site 151,  
20 then it may not be necessary for the administrator to deploy the  
21 disk subsystem 104 on the remote site 151. The administrator  
22 can then set up the remote disk subsystem 104. This set up  
23 includes copying data from the storage media (e.g., storage  
24 media 710 or storage media 807) to the remote disk subsystem

1 104. If the storage media is a removable media, then the  
2 administrator can copy data from this removable media to the  
3 remote disk subsystem 104. The configuration of the system for  
4 the copy procedure may vary and may depend on the environment of  
5 the administrator. The administrator can, for example, choose  
6 the configuration in Figure 4 or Figure 5 or other  
7 configurations, and can choose a suitable method for copying (as  
8 performed in block 307 in Figure 3).

9 As another example, if the storage media are disk drives  
10 (e.g., disk drives of the type that are similar to disk drives  
11 140) and are to be a part of the remote disk subsystem 104, then  
12 the administrator can put the disk drives into the remote disk  
13 subsystem 104. The administrator then configures these disk  
14 drives as part of the remote disk subsystem 104 (as also  
15 illustrated above in block 308 in Figure 3).

16 As another example, if the storage media is the remote disk  
17 subsystem 104 itself, then the set up of the storage media in  
18 the remote site 151 is completed in block 305 in Figure 3. The  
19 administrator then connects the remote disk subsystem 104 to the  
20 network 105 for the remote copy procedure. At this time, the  
21 master disk subsystem 103 also is typically connected to the  
22 network 105 (as also illustrated above in block 309 in Figure  
23 3). The administrator then configures the remote copy settings  
24 to permit remote copy operations (as also illustrated above in

1 block 310 in Figure 3). The administrator can then re-  
2 synchronize data between the master disk subsystem 103 and the  
3 remote disk subsystem 104 (as also illustrated above in block  
4 311 in Figure 3).

5 Figure 9 is a flowchart illustrating a method 900 of  
6 performing an initial copy at a manufacturer's site, in  
7 accordance with a specific embodiment of the invention. It is  
8 noted that to deploy the remote disk subsystem 104 on the master  
9 site 150 may be difficult in some cases. The master site 150  
10 and the manufacturer site may be connected by a higher speed  
11 network used for certain purposes such as initial copy  
12 procedures. In this embodiment, data copy is performed at a  
13 site of a manufacture in order to achieve higher initial copy  
14 performance. Thus, this embodiment provides a less costly and  
15 higher speed network without the requirement of having to deploy  
16 the remote disk subsystem 104 on the master site 150. It also  
17 noted that in another embodiment, the administrator can copy  
18 data at the site of the manufacturer by use of a storage media  
19 as similarly described above. In various embodiments, pre-  
20 copied disk subsystems are used.

21 In Figure 9, the administrator first deploys (901) a disk  
22 subsystem (such as the remote disk subsystem 104) at the site of  
23 a manufacturer. Alternatively, as similarly described above,  
24 the administrator can deploy a storage media at the site of the

1 manufacturer to perform the initial copy procedure described  
2 below. A split procedure is then performed (902). The split  
3 procedure was described above in the method for performing an  
4 initial copy at the master site 150. The administrator then  
5 initially copies (903) data to the remote disk subsystem 104  
6 from the manufacturer's disk subsystem. In this initial copy  
7 procedure, the administrator may use any suitable method such  
8 as, for example, (1) performing an initial copy by use of a  
9 higher speed network as similarly illustrated above in blocks  
10 202 to 204 in Figure 2, or (2) performing an initial copy at the  
11 master site 150 as illustrated above in block 303 in Figure 3.  
12 When the initial copy procedure is completed, the administrator  
13 can move (904) the data to the remote site 151. The  
14 administrator can move (905) the remote disk subsystem 104  
15 itself to the remote site 151. If the administrator has already  
16 moved the remote disk subsystem 104 to the remote site 151 and  
17 the disk drives (or other storage media) are used for copying the  
18 data from the site of the manufacturer, then the administrator  
19 can move (906) the disk drives. At the remote site 151, the  
20 administrator can install (907) the disk drives into the remote  
21 disk subsystem 104. The administrator then connects (908) the  
22 network 105 path between the master disk subsystem 103 and the  
23 remote disk subsystem 104. The administrator also configures  
24 (909) the master disk subsystem 103 and the remote disk

1 subsystem 104 for remote copy operations. The administrator  
2 then re-synchronizes (910) the master disk subsystem 103 and the  
3 remote disk subsystem 104. This re-synchronization method was  
4 similarly described above in the method for performing an  
5 initial copy at the master site 150 as illustrated in block 311  
6 in Figure 3.

7 Other variations and modifications of the above-described  
8 embodiments and methods are possible in light of the foregoing  
9 teaching. For example, the term "network administrator" is not  
10 limited to a single individual.

11 It is also within the scope of the present invention to  
12 implement a program or code that can be stored in an  
13 electronically-readable medium to permit a computer to perform  
14 any of the methods described above.

15 The above description of illustrated embodiments of the  
16 invention, including what is described in the Abstract, is not  
17 intended to be exhaustive or to limit the invention to the  
18 precise forms disclosed. While specific embodiments of, and  
19 examples for, the invention are described herein for  
20 illustrative purposes, various equivalent modifications are  
21 possible within the scope of the invention, as those skilled in  
22 the relevant art will recognize.

23 These modifications can be made to the invention in light  
24 of the above detailed description. The terms used in the

1 following claims should not be construed to limit the invention  
2 to the specific embodiments disclosed in the specification and  
3 the claims. Rather, the scope of the invention is to be  
4 determined entirely by the following claims, which are to be  
5 construed in accordance with established doctrines of claim  
6 interpretation.

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